

U. S. DEPARTMENT OF AGRICULTURE.

WEATHER BUREAU.

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INSTRUCTIONS TO
SPECIAL
RIVER AND RAINFALL OBSERVERS
OF THE WEATHER BUREAU.

BY

H. C. FRANKENFIELD,
PROFESSOR OF METEOROLOGY.

Prepared under direction of WILLIS L. MOORE, Chief of Weather Bureau.



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NOTE TO SPECIAL RIVER AND RAINFALL OBSERVERS.

This book of instructions will be carefully preserved. When an observer is relieved or is to be temporarily absent from his station he will turn it over to his successor, obtaining the latter's receipt therefor, which will be forwarded by mail to the official in charge of the district.

INSTRUCTIONS

FOR

SPECIAL RIVER AND RAINFALL OBSERVERS.

OBJECT OF RIVER AND RAINFALL OBSERVATIONS.

The river and rainfall stations of the Weather Bureau are maintained primarily for the purpose of giving warning of the approach, magnitude, and duration of high waters, and for forecasting water stages at all heights, in the interest of navigation on the inland waterways of the country. The river and precipitation data are also of great value to various other interests, particularly to those concerned with the problems of irrigation and water supply.

DISTRICT CENTERS.

For the better supervision and control of the work, the special stations are arranged in districts. These districts are under the direction of officials at regular meteorological stations of the Weather Bureau, designated as district centers. The centers are usually at the lower end of the districts.

All correspondence relating to the work of substations, such as the furnishing of supplies, renewal of gages, settlement of accounts, and employment of observers, is conducted through the official in charge at the district center to which the station is assigned.

Observers are furnished with penalty envelopes for correspondence with the district center and with the Central Office at Washington, D. C., on matters pertaining to the work of the station. No postage is required on penalty envelopes.

Persons accepting positions as special river and rainfall observers of the Weather Bureau become authorized agents of the United States, and are amenable to the laws in case of neglect of duty.

River gages are constructed at the expense of the United States, except where permission can be obtained to use those already installed by municipalities, counties, townships, or corporations.

Duplication of gages will be avoided when possible, both in the interest of economy and to prevent confusion arising from double records of stages.

The records of stages are preserved at Washington and printed from time to time. They are accessible to interested persons at all times.

SUPPLIES.

Supplies of blank forms, franked and addressed envelopes, rain gages, measuring sticks, and other necessary supplies are furnished to observers upon application to the official in charge of the district center. Timely requisition will be made for such supplies as are needed, and the needs of the station must be so anticipated as to allow ample time for the delivery of the articles from the Central Office at Washington, D. C., through the district center. One month is usually sufficient for this.

INSTRUCTIONS.

The duties of a river observer consist in noting on a form furnished for the purpose—

- First. The height of water on the gage, with change in 24 hours.
- Second. Depth of rain or melted snow, with times of beginning and ending.
- Third. Actual depth of snow, if any, since last observation.
- Fourth. Direction of wind.
- Fifth. State of weather.
- Sixth. Depth of snow, if any, on ground on 15th and last day of month; also date on which last snow of season disappeared.
- Seventh. Stage of river at crest of each flood, with hour of day, should it not occur at time of regular observation.

A postal card containing a record of the observations is also mailed daily, when required, to the official in charge of the district center.

A postal card (Form 1049, Met'l) containing the *original* record of the daily stages of water in the river is mailed on the last day of each month to the Chief U. S. Weather Bureau, Washington, D. C.

Telegraphic reports are also made under certain conditions as hereinafter set forth.

The duties of a rainfall observer consist in noting on a form furnished for the purpose—

- First. The depth of rain or melted snow, with times of beginning and ending.
- Second. Actual depth of snow, if any, since last observation.
- Third. Direction of wind.
- Fourth. State of weather.
- Fifth. Depth of snow, if any, on ground on 15th and last day of month.

A postal card containing a record of the observations is also mailed daily, when required, to the official in charge of the district center.

Telegraphic reports are also made under certain conditions, as hereinafter set forth.

All reports will be rendered to the officials in charge of the district centers, who will disseminate the information so as to best subserve the interests of the public.

The height of water on the gage should be noted to the nearest tenth of a foot each day, including Sundays and holidays.

This can only be done accurately when the water is placid; in a rough or turbulent stream, or when there is much wind, the waves prevent accurate readings. In such cases the tenths must be estimated as near as possible by taking the average of the highest and lowest marks on the gage which the water is seen to touch.

The depth of rain or of melted snow, or of melted snow and rain, must be given in inches and hundredths of an inch, properly separated by a decimal point.

A measurement of the actual depth of the snowfall since last observation must always be made and entered in inches and tenths of an inch.

In addition to measuring the depth of snowfall since the last observation, a measurement should be made of the actual depth in inches and tenths of an inch of the accumulated snow on the ground at the time of the observation on the 15th and last day of the month.

It is desired, if it can be readily determined, that the observer report in the space on the form prepared for that purpose, the date on which the last snow of the season disappeared.

Full instructions as to the methods to be used to obtain the above data will be found under the head of "To measure rainfall or snow fall."

The direction of wind will be designated by the eight principal points of the compass, viz: N., NE., E., SE., S., SW., W., and NW., legibly written. When there is no wind, the word "Calm" should be recorded.

The state of weather will be determined and recorded with reference to the degree of cloudiness, and whether or not precipitation is falling or likely to fall soon; thus when the sky is three-tenths or less covered with clouds, record "Clear;" four to seven-tenths, inclusive, "Partly cloudy;" eight to ten-tenths, "Cloudy;" and "Sprinkling," "Light rain," "Heavy rain," "Light snow," "Heavy snow," "Sleet," "Hailing," "Threatening," "Clearing," when these conditions exist. When light fog, light haze, or light smoke is observed with no clouds, the state of the weather will be recorded as "Clear."

Any unusual occurrences connected with the stages of the water in the river, such as the presence of floating ice or timber, the formation and breaking up of ice gorges and other obstructions should be noted. Thunderstorms, hailstorms, tornadoes, and earthquakes will also be recorded.

Observers should, when possible, have substitutes capable of performing all the duties of a river observer, in order that there may be no interruption of the work in case of sickness or unavoidable absence from the station on the part of the regular observer. Members of the observers' families are very often instructed in the work.

TIME OF OBSERVATION.

The observation of the river stage will be made daily at 8 a. m., 75th meridian time, except when otherwise directed.

In all cases the 75th meridian time of observation should be given in the proper space at the head of the form, whether 8 a. m. or some other time.

The observations in feet and tenths of a foot will be written in the first column of the monthly blank form.

When the stage is below the zero of the gage it will be written in the form with a minus (—) sign before it.

The rise or fall will be given in the proper column on the form in feet and tenths of a foot. When the change is a fall it should have the minus (—) sign placed before it.

SPECIAL OBSERVATIONS.

Special observations of the stage of water will be made at other times of the day than 8 a. m. when requested by the official in charge of a district center or by the Central Office in Washington, or when the river is near, at, or above the flood stage.

It is desirable to have a special observation of the highest stage reached by the water in the case of the very great rises, without any request from a district center. In many cases the stage in a rise will reach in the course of the day several feet above the 8 a. m. stage and fall several feet before the time of the next regular observation on the day following.

When the rise in a river is very sudden and great, and, in the judgment of the observer, dangerous to points below, the stage will be telegraphed to the district center and to the places most interested in the information, according to such special instructions as may be given to each observer.

Special observations will contain exactly the same information as a regular report, but the rainfall after being measured should not be emptied out of the gage, but left therein until the next regular observation, when, after measuring, it will be poured out.

RIVER GAGE.

A river stage is the vertical height of the water surface in feet above some definite plane, the zero of the gage usually, at, or somewhere near, the level of the lowest water that has occurred. A river gage is a device for observing the river stage.

When possible without too great expense, river gages are made vertical. They ordinarily consist of a plank or planks, usually 2 inches thick and 8 to 12 inches wide, fastened to a bridge pier or piling or other structure, and of sufficient length to cover the greatest range in height of water ever likely to occur. The planks are graduated to feet and tenths, and the height of the surface of the water in the river can be read on it by estimation to the nearest tenth of a foot.

Sometimes river gages consist of a strip of the surface of a stone pier dressed smooth so as to receive the necessary marking and numbering.

When a river gage can not be set vertically, it is laid along the bank according to the slope of the ground. It should then be made of heavy timbers, at least 6 by 6 inches, and preferably of oak, hard pine, or Oregon fir, embedded in the ground, with the top surface even with the surface of the ground on the river bank. Strap iron $\frac{1}{4}$ inch thick and 2 inches wide, is spiked along the top and upstream sides, and on the toppiece are cut the foot and intermediate marks. The even foot marks are also indicated by figures, in brass or paint, on the timber. The foot marks on a gage of this kind must be accurately located by a civil engineer.

Very substantial inclined gages are made of concrete or lengths of block stone, with bars of railroad iron inlaid, on which the foot marks are cut.

It is not always possible at the time of setting a gage to put the zero of graduation at the exact level of the lowest water apt to occur, or the lowest that has occurred in a long period of years. In such cases the gage should be finished as far down as possible, and completed when the water falls sufficiently low.

When a stage of water below the zero occurs it is read as a minus stage. It is desirable that the zero should be put so low that this will never occur, as the minus sign is apt to lead to confusion. The bed of the river channel usually makes the best zero mark.

When a gage is once established and a long record of readings made, it is not advisable to make any change in its zero on any pretext whatever, even if a stage lower than any ever before known should occur.

For the purpose of ascertaining from time to time any changes that may occur in the level of the zero of a gage or any of its marks, a bench mark should be established close by the gage or somewhere in its vicinity. A bench mark consists of some accessible, presumably permanent, point or surface, the difference in level between which and the zero or some other mark on the gage is known by actual leveling between the two. When this difference is found to vary it is presumed it indicates a corresponding change in the level of the marks of the gage, requiring either adjustment of the gage or correction of its readings.

A bench mark is essential in case a river gage is to be repaired or renewed, in order that the new gage may be set at exactly the same level as it was before. On a bridge pier the top surface of the largest stone accessible in the top course of masonry is often used as a bench mark. Sometimes a bench mark is the top surface of a large stone

buried in the ground specially for the purpose of establishing a permanent surface. Prominent surfaces in stone buildings are good places for permanent bench marks. A copper bolt, or metal plate, set in the stone wall of some public building, such as the customhouse, post office, or city hall, is a common device for a bench mark in a large city.

The river gages used by the Weather Bureau are partly shown in figures 1, 2, 3, and 4. The design best adapted to any particular location will be used in each case.

The specifications to be followed in procuring bids for the construction of these gages are as follows:

SPECIFICATIONS FOR RIVER GAGE SHOWN IN FIG. 1.

The river gage will be made of sound pine or oak timber, free from knots or shakes, 2 inches in thickness, 12 inches in width, and of such a length as to extend, if possible, from 2 or more feet below the zero point to about 5 feet above the highest known water. The face of the plank upon which the graduations are to be made, and the top, bottom, and sides, will be planed smooth, and will receive two coats of the best white-lead paint. The face will then be graduated as follows:

Commencing at the point which will correspond to the zero, graduate the gage both above and below that point in feet and tenths of feet.

The graduations will be chiseled or burnt into the wood to the depth of about one-eighth of an inch and then given two coats of the best black paint. The marks for whole feet will extend entirely across the face of the gage; those for half-feet one-half the distance across, beginning on the left side, and those for the intermediate graduations one-fourth of the distance

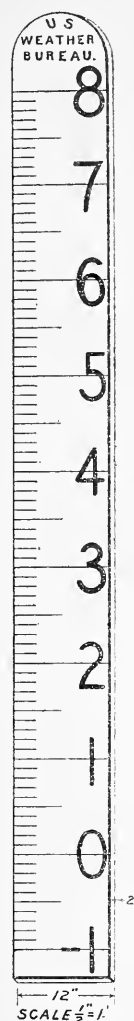


FIG. 1.

across, beginning on the left side. Whole feet will also be shown by the appropriate figures, 6 inches in height, on the right side of the gage, and so placed that the marks for whole feet will exactly bisect the figures. The figures will also be chiseled or burnt into the wood to the depth of about one-eighth of an inch, and then given two coats

of the best black paint. The legend, U. S. Weather Bureau, should be painted in black across the top of the gage.

Having graduated the gage, select a pile or other stationary object on some portion of the levee, wharf, or bank where the gage will be secure from injury. Lower the gage into the water, taking care to keep it in a vertical position until it touches the bed of the river or its zero is the point of lowest water; then securely fasten it by spikes or bolts.

SPECIFICATIONS FOR RIVER GAGE SHOWN IN FIG. 2.

Procure a piece of pine, cypress, or oak timber about 6 by 6 inches, and of sufficient length to cover the full range of the river between extreme low and high water marks. This timber will be placed in

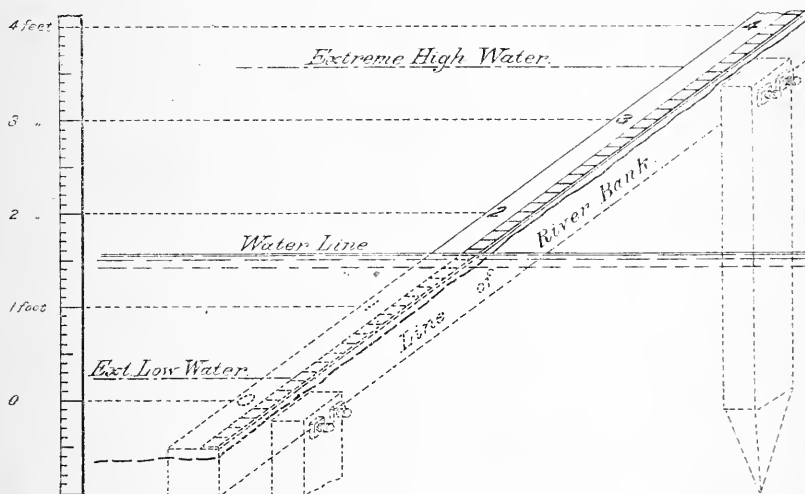


FIG. 2.

the river bank, firmly embedded in the earth, leaving $1\frac{1}{2}$ inches exposed above the level of the ground.

To secure this form of gage thoroughly it will be necessary to attach it to 4 by 6 or 6 by 6 inch oak, cedar, locust, or fir posts, driven 6 feet into the ground, and placed 6 feet apart. The upper edge of the gage should be planed smooth, and a strap of iron, $\frac{1}{4}$ by 2 inches screwed along the top on the upstream side, and graduated in feet and tenths of feet, after being placed in position, taking the point of lowest water, or that which has been selected as the zero of the scale, and locating the feet and tenths both above and below that point. The graduations for this gage will be the same as for the gage shown in figure 1. Especial pains should be taken in graduating the gage to see that the distances marked off upon it for each foot and its subdivisions correspond exactly to a vertical foot and its subdivisions of which it is a measure. This should be done by means of an ordinary carpenter's square and a spirit level.

It is also very desirable that this form of gage should have its top surface covered with two coats of the best white lead or zinc paint, with the proper figures opposite the even footmarks on the iron strap in black paint and not less than 4 inches in length. Figures should also be burnt in before painting, as permanent markings are thereby secured.

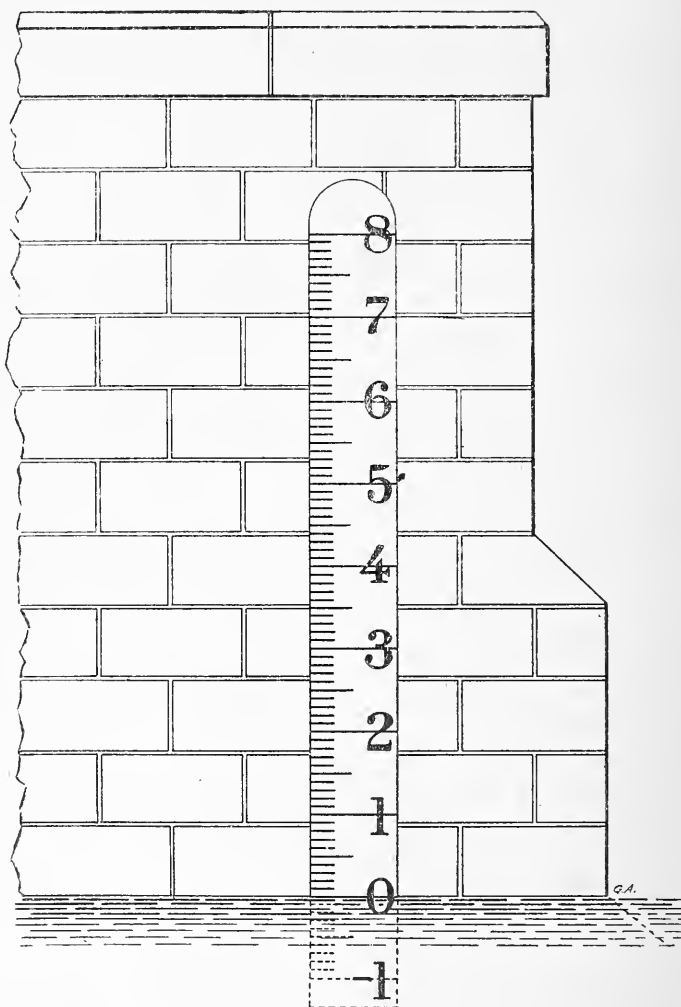


FIG. 3.

SPECIFICATIONS FOR RIVER GAGE SHOWN IN FIGURE 3.

Where a stone pier or abutment is available, a very durable gage can be made by dressing a face, 12 inches in width, from extreme low water to as far above as may be necessary. The dressed surface should be covered with two coats of the best black paint, preferably

asphaltum, after all holes and indentations in the pier have been filled with cement.

The space, both above and below the point at which the zero will be placed, will be graduated with two coats of the best white lead or zinc paint into feet and tenths of feet. Markings for whole feet will extend entirely across the gage; those for half feet one-half the way across, beginning on the left side; and those for the intermediate graduations one-quarter of the way across, beginning on the left side. All markings will be one-quarter of an inch in width. The figures for the whole footmarks will be in white, 5 inches in height, and the center of each figure must be over the foot line at the right.

SPECIFICATIONS FOR THE CONSTRUCTION AND INSTALLATION OF GAGE BOXES FOR CHAIN AND WEIGHT RIVER GAGES.

(United States Geological Survey pattern.)

The material, except lumber and paint and heavy bolts, will be furnished by the Weather Bureau.

The box will be made of $\frac{7}{8}$ -inch oak, cypress, or hard pine lumber, planed smooth on both sides, and free from knots and shakes. It will be 15 feet in length, 6 inches in width at the bottom (inside measurement), 6 inches in height on one side and 4 inches on the other. The top will be fastened to the 4-inch side by 6-inch hinges, the hinges being secured by $1\frac{1}{4}$ -inch tire bolts and clamped inside the box with washers and nuts. The hinges will be placed one at each end of the box and also at intervals of 3 feet, making 6 hinges in all. They will be bent around the bottom of the box so that the lower screw bolt of each can be driven into the box from the underside. A hasp and staple will be attached about 3 feet from each end of the box in the usual manner, using $1\frac{1}{4}$ -inch tire bolts. The locks will be attached with staples or clamps that can be clinched inside the box.

The pulley will be mounted on the 6-inch side of the box, as shown in diagram attached, and directly below it the bottom of the box will be sawed out.

A slot one-half inch in depth and width will be cut in the middle of the top of the end of the box nearest the pulley. When not in use, the weight can then be drawn up, lifted over the end, and placed in the box, with the chain in the slot. This will admit of the box being securely locked, leaving only a few inches of chain exposed.

The scale will be graduated in feet and tenths of a foot on the 6-inch side of the box (inside), beginning at the inner edge of the pulley frame and ending at the far end of the box. The whole feet will be marked with 2-inch staples, half-foot marks with 1-inch staples, and intermediate graduations with $\frac{1}{2}$ -inch staples. One staple will be used at each foot and half-foot mark and intermediate

graduation. The brass figures for the whole feet will then be screwed to the bottom of the box. The scale limits of each will be furnished

by the official in charge of the district center. A hook will be provided at the far end of the box to hold the ring secured to the end of the chain.

When the zero shall have been established, the weight will be lowered so that its bottom just touches the zero point. The link of the chain directly opposite the zero mark on the scale will then have a rivet driven into it and flattened on both sides so that it will remain firm. Should it be necessary to record river readings beyond the scale limits of the box, the rivet in the chain will be drawn up so that it will be exactly opposite the highest footmark on the scale. Another rivet will then be driven into that link of the chain exactly opposite the zero mark on the scale, and readings taken, using this second rivet as a base. A third rivet can also be added if necessary. In recording readings which are beyond the scale limits of the box the second rivet will be used as a zero mark instead of the first, and there will be added to the observed reading the distance between the rivets, which will correspond to the highest reading on the scale.

The box will be securely attached by its 6-inch side to the guard rail or side of bridge, the former preferred.

The whole box will be painted

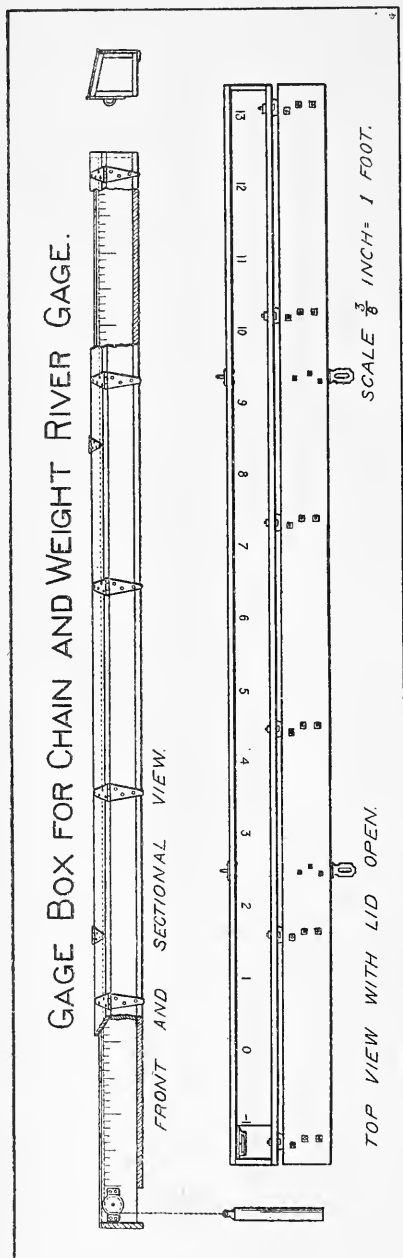


FIG 4.

with two coats of best white lead or zinc paint.

In making requisition for material for these gages officials in charge of river districts will state the length of sash chain required.

DESCRIPTION OF THE MOTT RIVER GAGE.

Box.—The gage box and doors are constructed of sand-dried oak lumber dressed on all surfaces, $\frac{7}{8}$ -inch stock, and inside dimensions as follows: Height, 18 inches; width, 18 inches; depth, $7\frac{1}{2}$ inches.

Doors.—The box has two doors secured with extension hinges in such manner as to permit the doors to swing back against the sides of the galvanized-iron box. The entire outside surface of the box, excepting the bottom, and including the doors, is covered with No. 24 galvanized iron. The joints of the galvanized-iron cover are lapped and soldered, making the cover water-tight. The galvanized-iron cover of the box is painted with two coats of dark-green mineral paint, with a label on the doors of the box bearing the words "Property United States Weather Bureau. Penalty for Interference."

Lock.—The box is fitted with a brass mortise lock, using the same key as is used in the standard padlock for the chain and weight gages of the United States Weather Bureau and United States Geological Survey.

Mechanism.—The box is fitted with a tape reel consisting of an aluminum brake wheel and a brass spider, mounted on a turned cast-iron standard and fitted with a wooden handle. A leather brake strap and suitable levers for releasing the brake are provided. The brake strap is attached to a brass coil spring of sufficient strength to hold the weight and tape in any position. An iron guide wheel running on a turned axle, secured in the box by a cast-iron standard, is also provided.

Tape and gage.—The tape is made of phosphor bronze, $\frac{1}{30}$ inch in thickness and $\frac{1}{4}$ inch in width. It is nickeled throughout, excepting the relief in which the figures are etched, which is plain. The tape, accurately subdivided to feet, with foot marks numbered consecutively between such limits as may be necessary, is furnished with each gage. A 1-foot scale divided into 100 parts, and having every fifth division mark suitably numbered, is placed in the box so as to stand cornerwise back of the tape in a vertical position. This scale is made of No. 16 gage iron, enameled in black and white with six coats of enamel, and is attached to an iron bar which projects upward through the top of the box, the projecting end being covered by a cast-iron cap or cover attached to the box by screws, the object being to provide a suitable bench or reference mark outside the box.

The 1-foot scale is adjustable vertically. A standard weight of the pattern used by the United States Weather Bureau and the United States Geological Survey is provided with each gage, together with a clip and wire for attaching the same to the tape. The gage weight is painted with two coats of white enamel paint.

Miscellaneous.—Each gage contains a covered compartment for the observer's record card, etc., instructions for erecting a gage in various

positions, for attaching the weight, checking the gage datum, and operating the gage.

A rectangular wooden down spout, 16 inches in length, with screw for attaching the same, is provided with each gage.

Each gage is also provided with a screw driver and a $\frac{3}{8}$ -inch twist drill for use in erecting the gage.

Operation.—Release brake and slowly unwind tape until weight reaches water. Do not run tape all out without holding reel handle. Brake will hold reel in position, and observer can stand to one side to see that tip of weight just touches water. Read number of whole feet on bronze tape and tenths of a foot on enameled scale. The figure on the tape standing opposite some part of the 1-foot scale gives the whole feet; the number of tenths and hundredths on the 1-foot scale opposite the index of the number on the tape gives the decimal or fractional portion of the gage reading.

For example, if the number 7 on the tape stands opposite 60 on the enameled scale, the gage reading would be 7.6 feet.

Erection.—The gage may be bolted to the handrail of a bridge, if not liable to interference, one side being fastened to tiebars that extend down to the floor of the bridge. It may also be secured to a platform extending beyond the handrail, the bottom of the box being on a level with the top of the rail. When there is no handrail, as on most railroad bridges, the gage may be bolted or secured to vertical bridge members, or it may stand on horizontal bridge chords, or be attached to two sleepers at their ends. In all cases room must be provided for the unobstructed movement of the weight.

Mott gages ready for installation will be supplied from the Central Office at Washington, D. C., and bids for installation only will be necessary.

In each instance the exact distance from the zero stage of the water to the bottom of the gage box when in position must be furnished.

RAIN GAGE.

EXPOSURE OF RAIN GAGE.

The exposure of the rain gage is a very important matter. The most serious disturbing effect in collecting rainfall is the wind. In blowing against the gage the eddies of wind formed at the top and about the mouth of the gage carry the rain away, so that too little is caught.

Observers will take particular care in selecting a good place for the location of a gage, as the value of the records is sometimes greatly impaired by improper exposure. It is scarcely necessary to say that every precaution should be taken to protect gages from the interference of animals and unauthorized persons. Select, if possible, a position in some open lot as unobstructed as possible by trees, build-

ings, or fences. Such a place in general affords the best exposure. Gages should be exposed upon roofs of buildings only when necessary, and then the roof should be flat, or nearly so. The middle portion of a flat unobstructed roof generally gives the best results.

Rain gages in slightly different positions differ greatly in the depth of rain indicated. Within a few yards of each other two gages may show a difference of 20 per cent in the rainfall in a heavy rainstorm. The stronger the wind the greater the difference is apt to be. In a high location eddies of wind produced by walls of buildings divert rain that would otherwise fall in the gage. A gage near the edge of the roof, on the windward side of a building, shows a less rainfall than one in the center of the roof. The vertical ascending current alongside of the wall extends slightly above the level of the roof, and part of the rain is carried away from the gage. In the center of a large flat roof, at least 60 feet square, the rainfall collected by a gage does not differ materially from what is collected at the level of the ground. A rain gage mounted on a mast at the height of 43 feet collects only 0.75 as much as at the ground; at 85 feet, only 0.64; and at 194 feet, only 0.58. A gage on a plain with a fence 3 feet high around it at a distance of 3 feet will collect 6 per cent more rain than without the fence. These differences are due entirely to wind currents.

INSTRUCTIONS FOR THE USE OF THE RAIN GAGE.

Description of gage.—The rain gage consists of the following parts: The receiver *A*; the overflow attachment *B*; the measuring tube *C*.

The top cylindrical portion of the receiver, marked *a* in figure 5, is exactly 8 inches in diameter, inside, and is provided with a funnel-shaped bottom, which conducts any precipitation falling into the receiver into the tall cylindrical measuring tube *C*, the total height of which, inside, is exactly 20 inches. The diameter of this tube is much smaller than the large receiving tube *a*, being only 2.53 inches. In consequence of this a small amount of rain falling into the receiver and flowing into *C* fills the latter to a depth greater than the actual rainfall in proportion as the area of the receiver is greater than the area of the measuring tube. In the standard gages of the Weather Bureau the depth of the rainfall, in accordance with this principle, is magnified just 10 times. The receiver *A* has a sleeve *d*, figure 5, which slips over the tube *C*, and very effectually prevents any loss of rainfall. Again, when the rainfall is very heavy the tube *C* may be more than filled. In this case, to still prevent loss, a little opening, shown at *e*, figure 5, is made in the sleeve *d*, just on a level with the top of the tube *C*.

The excess of rainfall escapes through this opening, and is retained in the large overflow attachment *B*, and can be measured afterwards, as will be described below. The diameter of the overflow attachment

in the latest style gage is now made just 8 inches inside diameter. The object of this is to be able to use this portion of the instrument as a snow gage, as will be explained hereinafter.

RAIN GAGE AND SUPPORT.

The box in which the gage is shipped to the observer is expressly designed as a stand for the instrument, and should be opened at the head, which is fastened by screws. Set the box up as nearly vertical as possible at the place selected for the exposure, and secure it in this position by driving down four stakes alongside, in the manner indicated in figure 6. Care must be taken to have the gage in a truly ver-

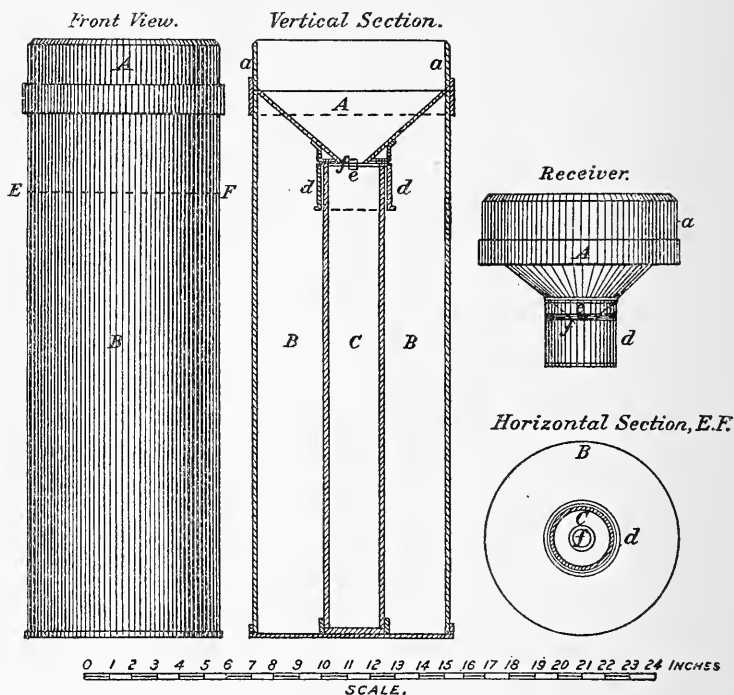


FIG. 5.—Rain gage.

tical position. Slip in the head and lower it to the level of the screw holes in the sides of the box about 10 inches from the bottom, where the head will be securely fastened with the screws taken out in opening the box. The gage can now be placed inside, and appears as shown in figure 6.

TO MEASURE RAINFALL AND SNOWFALL.

RAINFALL.

The rain-gage measuring stick is graduated into inches and tenths of inches. Remembering that the actual depth of the rainfall is magnified 10 times, as explained above, it is plain that if we find the water

10 inches deep in the measuring tube the real rainfall must have been only 1 inch deep; or if the water in the tube is only one-tenth inch (or, written as a decimal, 0.1 inch deep) the rainfall must have been only one one-hundredth inch (or, written as a decimal, 0.01 inch).

To save observers the trouble of always thinking about the magnification, and to avoid possible errors in reports, the numbers on the graduations of the measuring sticks are not actual inches, but have all been divided by 10, and thus represent the actual rainfall. Moreover, these numbers are expressed in hundredths of inches of rainfall, and are written as decimal fractions. Thus the 10-inch line is numbered 1.00 (read one and zero hundredths), which is the depth of rainfall in inches corresponding to 10 inches of water in the measuring tube; similarly the 1-inch line is numbered 0.10 (read ten one-hundredths), which again is the depth of rainfall in inches corresponding to 1 inch of water in the tube.

The depth of the water is measured by inserting the measuring stick into the gage through the small hole in the funnel. When the stick reaches the bottom of the measuring tube it should be held for one or two seconds and then quickly withdrawn and examined to see at what division of the graduation the top of the wetted portion comes. The numbering of this division, *as stamped on the stick*, gives, as has just been explained, the actual depth of rainfall, and in making out records and reports observers should *always use the decimal expressions*. Of

course, it will rarely happen that the top of the wetted portion will fall exactly upon one of the numbered lines—it will generally be on or near one of the shortest lines. Thus, for example, suppose the watermark comes to the sixth short line beyond the line numbered 0.80, the proper record to make in this case would be 0.86-inch rainfall. The number of short lines, reckoned from the numbered line next lower, are always to be inserted in place of the 0 in the stamped numbers.

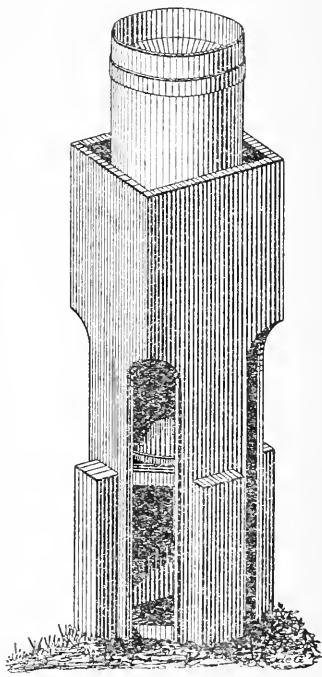


FIG. 6.—Rain gage and support.

Observers should always be careful to put the stick into the gage so that the end at which the numbering begins goes to the bottom, and the stick passes through the middle of the tube; for if the stick is placed near the sides the water is sometimes drawn up by capillary action into the narrow space between the stick and the tube so as to wet the former entirely too high and give very erroneous records.

After measuring and recording in this way the precipitation found in the gage the top should be removed, the measuring tube emptied and drained, and the gage put in position again. Observers should be careful after emptying the gage to replace the measuring tube so that the bottom stands within the ring in the middle of the bottom of the overflow, and in putting on the receiver to see that it passes over the measuring tube and rests squarely down upon the overflow.

When the amount of rain that has fallen more than fills the measuring tube, some care is required to determine the total rainfall. First, carefully remove the receiver so as not to spill any of the water in the measuring tube, which should be exactly full. If some water has been slopped out and the measuring tube is not exactly full, the amount of water remaining must be accurately measured with the stick as already described. The tube is then lifted out slowly and carefully, if full, so as not to spill any of the water into the overflow, emptied, and allowed to drain a moment or so. The water remaining in the overflow is then poured into the measuring tube, care being taken not to lose any, and measured in the usual way. Suppose this is found to be 0.47 inch rainfall, then, remembering that the measuring tube is just 20 inches high, the total rainfall will be 2 inches plus 0.47 inch = 2.47 inches. Or, in case some water was spilled from the measuring tube, the 0.47 inch should be simply added to the first measured amount to give the total rainfall.

SNOWFALL.

During the winter season, especially in those climates where the precipitation is nearly all in the form of snow, only the overflow attachment will be exposed in the support as a snow gage, removing the receiver and measuring tube to the house. These parts can not be used for measuring snow, and even if rain should occur it would be very apt to freeze and injure the measuring tube.

When the overflow collector is unprotected from the wind its catch represents the true amount of snow only in the case of precipitation during calms or very light winds. On windy occasions the catch is often highly inaccurate and in the absence of special appliances such as described in the Appendix, the true quantity must be found, if possible, by measuring a section of the freshly fallen snow cut out by forcing the overflow, mouth downward, through the layer and then

slipping a thin board or sheet of metal underneath so as to separate and lift up the section of snow thus cut out.

Assuming that a representative quantity of snow has been obtained in the overflow, a measurement may be secured by placing the vessel in a warm room until the snow has melted and then measuring the water in the measuring tube in the usual way.

The method just described is objectionable, owing to the time required and to the loss of the snow or water by evaporation. The following plan is much better: Take the overflow into the room and pour into it *one measuring tube full of water to the brim*, preferably warm. In cases of deep snowfall more water will be required. This will melt, or at least reduce to a fluid slush, a considerable amount of snow. The measuring tube should then be filled to the brim from the melted contents of the overflow and emptied; thereby discarding a quantity of water equal to that added. The remaining water in the overflow, when measured in the tube, then gives the actual depth of melted snow.

In addition to this measurement by the gage a measurement will be made of the actual depth in inches of the snow on the ground. Select a level place of some extent, where the drifting is least pronounced, and measure the snow in at least three places. The mean of these measurements will give the snowfall, which is to be entered in the column of the report headed "depth of snowfall in inches." Whenever it is impracticable to melt the snow as described in the preceding paragraph, one-tenth of this mean will give an approximate value, in water, for the snow which could not be melted. This value must be set down in the proper column of the report in precisely the same manner as rainfall or snow melted in the gage. After snowfall has once been measured the same snow should not be measured at subsequent observations. Any fresh snow, however, should be measured and recorded as it falls. For additional instructions for measuring snow see detailed description of methods and apparatus in Appendix, Circular E, Instrument Division, third edition.

Observations of rainfall should be made at the time of river observations, and the gage should be emptied of all the water it may contain as soon as it has been measured.

If no rain, snow, or hail has fallen during the period of observation, make the entry ".00" in the proper column. If the amount is too small to measure, make the entry "Trace" or "T."

It is particularly important in the interest of accuracy that the observations be recorded as soon as made and that the daily entries be made each day. Even if no rain has fallen, the observer should bear in mind that his official record of that fact is very important.

Snow-cutting tubes and scales.—The type of measuring apparatus now to be described, and illustrated in figure 7, is designed to secure

accurate observations of the depth and water contents of the whole layer of snow on the ground.

These data are of great practical value in all problems of hydrology, especially at the close of winter seasons and the general breaking up of icebound conditions.

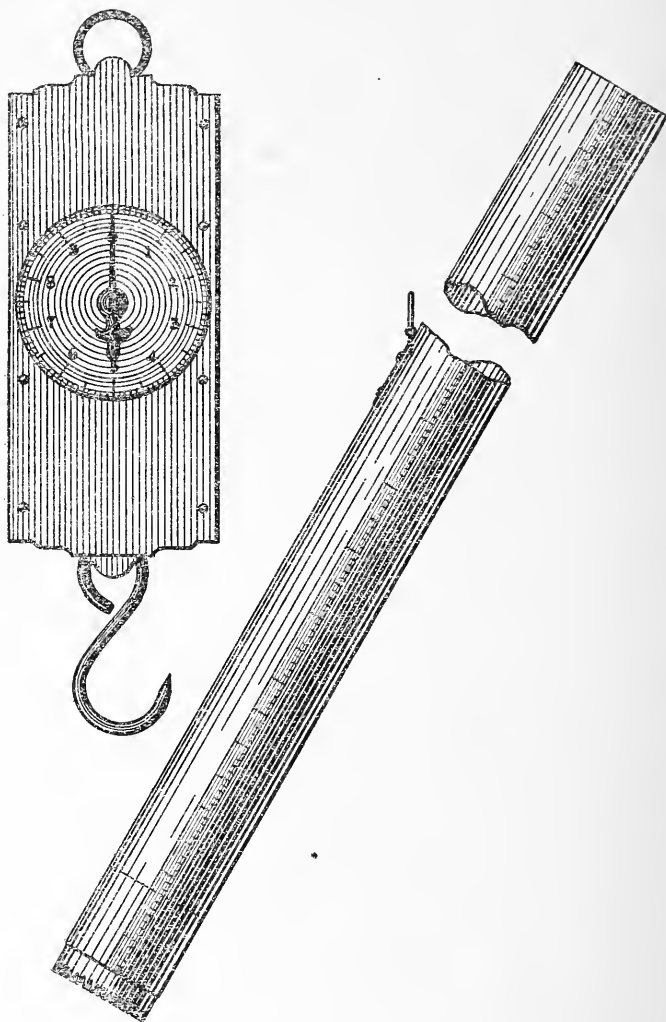


FIGURE 7.—Snow-cutting tubes and scales.

The tubes are made of galvanized sheet iron; they are about $2\frac{1}{2}$ inches in diameter, and are of greater or less length, according to climatic conditions of different sections. For the great majority of stations in the United States, tubes 50 inches long meet every ordinary requirement, but long tubes and sectional tubes are needed for proper measurement of deep beds of snow, such as are found in the western

mountains. One end of the galvanized tube is reenforced by a piece of seamless steel tubing, 6 or 8 inches long and of smaller diameter, which is forced tightly *inside* the galvanized tube, the two being securely riveted together. The slightly projecting end of the steel tube is coarsely serrated with keenly cutting teeth to facilitate perforating icy incrustations, or ice itself in the snow beds.

The outside of the tube may be provided with a scale of inches which for permanence and accuracy is engraved on a separate piece of metal tape (brass, dull nickel finish) fastened to the tube. A ring secured to the side of the tube permits it to be attached to an appropriate spring balance for weighing. The dial of the balance is graduated and figured to show the water equivalent of the contents of the tube. The whole dial represents 10 inches of rainfall, with subdivisions to inches and tenths. As the individual spaces are about $\frac{1}{8}$ inch, estimations to hundredths can be made, if this order of accuracy is considered necessary.

The tubes are decidedly the best means to employ in measuring deep beds of snow, but other methods are better for thin layers of freshly fallen snow. The proper tare allowance for the empty tube must generally be determined and applied to readings.

It may be well to remark here that, in case of measuring snow layers of small thickness with the tubes, better and more accurate average values can be obtained by cutting out two or possibly three sections at different points and collecting and weighing all of them in the tube at once. The observed net weight must of course be divided by the number of samples taken.

Snow-cutting tubes and scales are described here for the general information of River Observers, but the instruments are furnished only in special cases. For full particulars concerning methods of snow-fall measurement, observers should consult Weather Bureau Circular E, Instrument Division, third edition.

RECORDING OBSERVATIONS.

Form 1006, Met'l.—The record of the observations made at the station for the month, and should be filled up in accordance with the instructions printed on the back of the form.

The form should be mailed to the official in charge of the district center on the first day of the succeeding month.

Before mailing, a copy must be made by the observer in the book furnished for that purpose.

Form 3024, Tel.—For telegraphing reports in accordance with instructions hereinafter given.

Form 1084, Met'l (postal card).—For reporting the daily observations to the official in charge of district center or to other officials when specially authorized.

Form 1049, Met'l (postal card).—For reporting the record of the stage of water in the river for the month, to the Chief United States Weather Bureau, Washington, D. C. This is the *original record* of river stages.

PROPERTY.

When property and supplies are furnished to an observer, an itemized receipt therefor will be immediately mailed to the official in charge of the district.

When an observer is relieved from charge of a station, he will make out a list in triplicate of all Government property in his possession, and append at the bottom thereof the following certificate:

(Date) ———, 19—.

I certify that I have this day received from ——— (name of former observer) the above-mentioned articles in good condition unless otherwise specified hereon.

(Name of new observer) ———.

One copy of this report will be mailed to the official in charge of the district, one given to the new observer, and the third retained by the retiring observer.

When from any cause any article of property becomes unserviceable or in need of repairs, the fact must be at once communicated to the official in charge of the district for such action as he may deem proper and necessary.

The Chief of the Weather Bureau reserves the right to withhold payment from any person who persistently neglects to make his reports accurately and forward them promptly. Payment will be made quarterly.

REPORTS, WHEN TELEGRAPHED.

Some river observers, when specially instructed, telegraph daily stages to the district center, others only when the river reaches a certain height on the gage, and still others when the water is near, at, or above the flood stage.

In all cases, however, when the rainfall in the preceding twenty-four hours equals or exceeds 1 inch (or less in special cases), the observer will take a reading of the river gage and telegraph it, together with the amount of precipitation, direction of wind, and state of weather at the time of observation, to the official in charge of the district center.

Telegrams concerning the formation or breaking up of ice gorges, of heavy drift, or other obstructions in the river, when of sufficient extent to endanger navigation or destroy property, will be sent to the district centers and places specially authorized. The telegrams should give, in as few words as possible, the location and extent of the dam or obstruction.

Observers will not prepay telegrams on official business, as settlement will be made by the Washington Central Office direct with the telegraph companies sending the reports.

TELEGRAPHING REPORTS.

Telegraphic reports will contain the fullest information possible within a limit of twenty words, including the address and signature.

Reports for telegraphic transmission will be written on Form 3024 Tel., in the following order: First, the word "observer"; second, name of the place to which the report is to be telegraphed; third, name of station from which report is telegraphed; fourth, time of observation *if other than 8 a. m., 75th meridian time*; fifth, state of weather; sixth, stage of river; seventh, a word to indicate the action of the water, as "rising," "falling," or "stationary," as the case may be; eighth, depth of rainfall; ninth, depth of unmelted snow in inches; tenth, surname of observer sending the report.

Reports of regular observations taken at 8 a. m., 75th meridian time, need not contain the time of observation. If no rain or snow has fallen since last observation, and there is no snow on the ground, no mention need be made of the fact in the telegraphic report. The direction of the wind will not be sent, unless specially called for by the official in charge of the district center.

The rising or falling feature of a river is especially important at the high stages when the crest of a flood wave is approaching. Should the river become frozen, the information will be included in the telegraphic report.

The reports should be carefully and legibly written in letters that can not be misunderstood. Observers are advised to write messages, whenever possible, in print letters instead of a running hand. Care should be taken to so make the script or running hand letters that an "o" may not be mistaken for an "a," a "t" for an "l," an "i" for an "e," and so on. The actual stage of the river in feet and tenths of a foot will be spelled out, as "twenty-four feet six," "twenty feet two," etc.; the rainfall in inches and hundredths of an inch will be spelled out, as "one inch twenty-two," "three inches five," etc. The word "rising" or "falling," coming between the stage of water and the amount of rainfall, will prevent mistakes by confusing the tenths of a foot with the inches of rainfall. When less than one inch of rainfall is to be reported, the word "hundredths" should be added, as "seventy-four hundredths," "six hundredths," etc.

Messages should be filed at the telegraph office as soon as practicable after the observation has been taken. One copy of the telegram will be given to the operator at the telegraph office and one copy retained by the observer.

The following is an example of a report taken at 8 a. m., 75th meridian time. The river stage is above the zero of the gage and the ground is covered with snow. The translation follows the report:

CLINTON, TENN., *March 1, 1901.*

TO OBSERVER,

Chattanooga, Tenn.

Clinton cloudy twelve feet five rising one inch sixty-two snow six Jones.

[Translation.]

Observer, Chattanooga.....Address of Weather Bureau observer at Chattanooga, Tenn.

Clinton.....Name of river station at Clinton, Tenn.

Cloudy.....State of weather.

Twelve feet five.....Stage of river 12.5 feet.

Rising.....River rising at time of observation.

One inch sixty-two.....Amount of rainfall since last observation, 1.62 inches.

Snow six.....Unmelted snow on ground 6 inches.

Jones.....Name of river observer.

The following is an example of a report taken at 2 p. m., 75th meridian time. The river is below the zero of the gage and there has been no rain or snow. The translation follows the report.

HELENA, ARK., *April 20, 1901.*

TO OBSERVER,

Memphis, Tenn.

Helena two p. m. clear minus two feet eight falling Brown.

[Translation.]

Observer, Memphis.....Address of Weather Bureau observer at Memphis, Tenn.

Helena.....Name of river station at Helena, Ark.

Two p. m.....Time of observation, 2 p. m., 75th meridian time.

Clear.....State of weather.

Minus two feet eight.....Stage of river, -2.8 feet, i. e., 2.8 feet below the zero mark on the gage.

Falling.....River falling at time of observation.

Brown.....Name of river observer.

TABLE FOR CONVERTING INCHES INTO TENTHS OF A FOOT.

If the river gage is graduated in feet and inches, the inches will be converted into tenths of a foot by the following table before telegraphing:

- 1 inch of water equals one-tenth (0.1) of a foot.
- 2 inches of water equal two-tenths (0.2) of a foot.
- 3 inches of water equal two-tenths (0.2) of a foot.
- 4 inches of water equal three-tenths (0.3) of a foot.
- 5 inches of water equal four-tenths (0.4) of a foot.
- 6 inches of water equal five-tenths (0.5) of a foot.
- 7 inches of water equal six-tenths (0.6) of a foot.
- 8 inches of water equal seven-tenths (0.7) of a foot.
- 9 inches of water equal eight-tenths (0.8) of a foot.
- 10 inches of water equal eight-tenths (0.8) of a foot.
- 11 inches of water equal nine-tenths (0.9) of a foot.

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